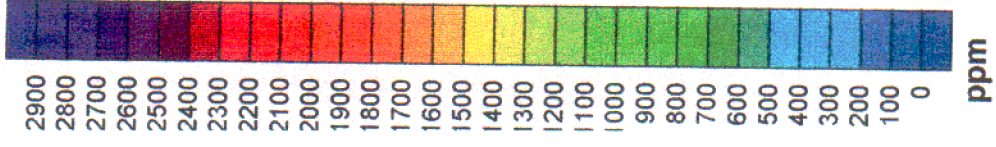
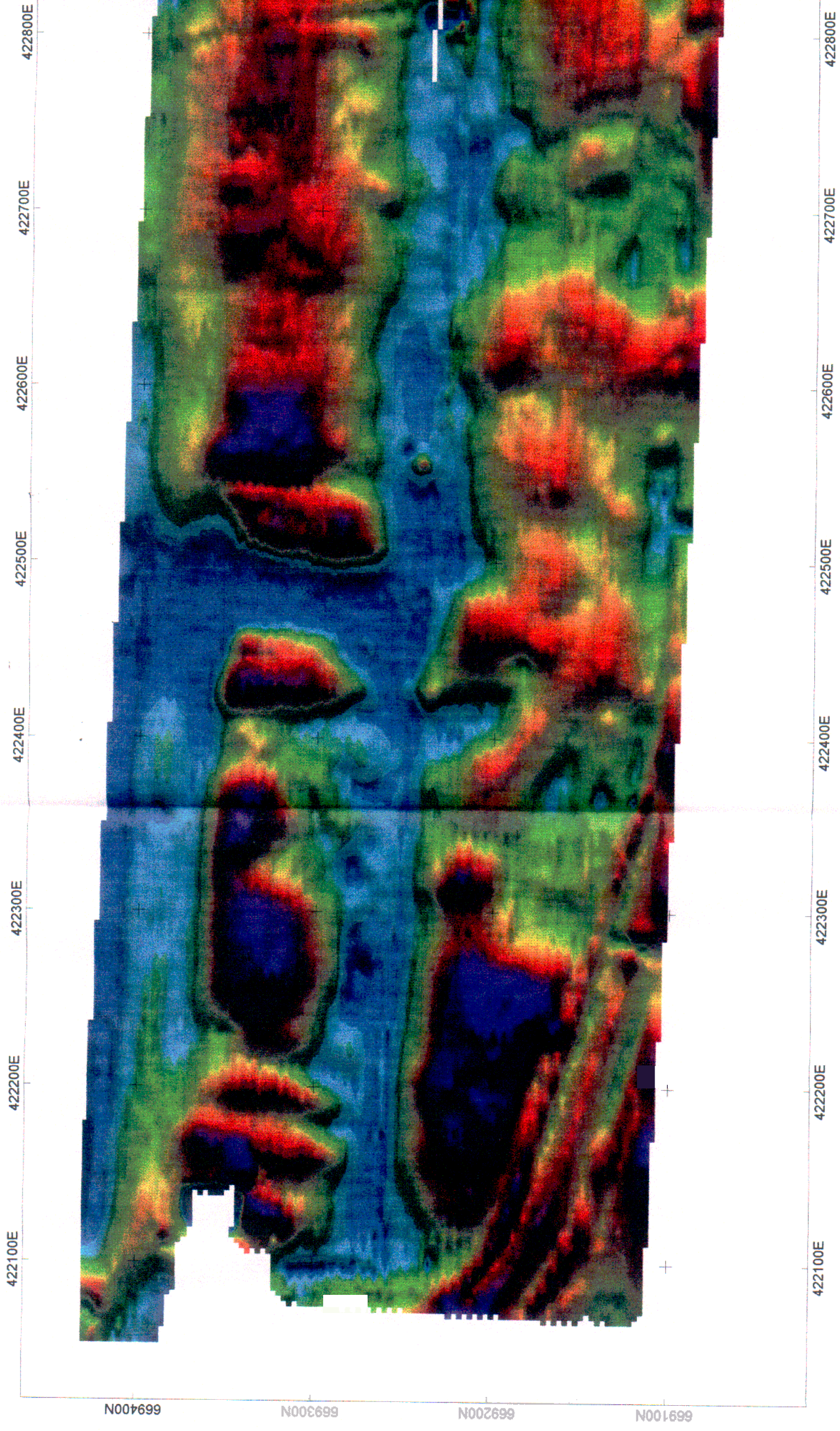
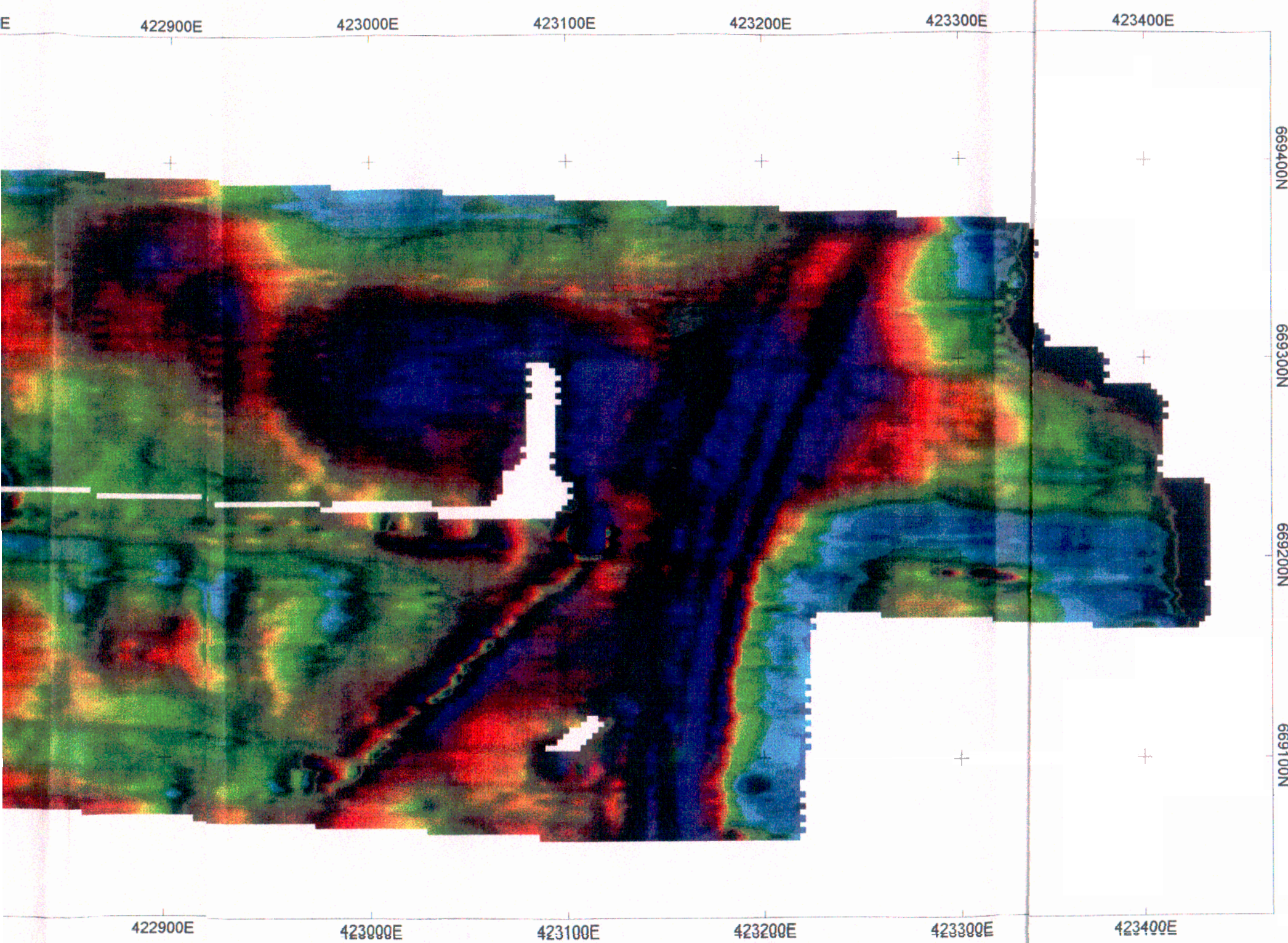


LIMITCO

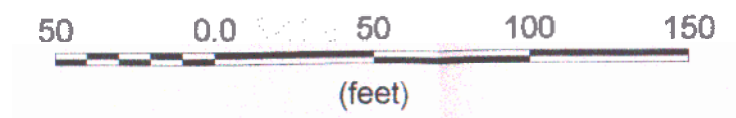
SDA Pits 4-6-10
PLATE 7
GEM300: 5610 Hz

Harding Lawson Associates/GeoSense





Scale 1:720



LIMITCO
SDA Pits 4-6-10 PLATE 8 GEM300: 19950 Hz
Harding Lawson Associates/GeoSense

APPENDIX B - Coordinate system

The Pit 4-6-10 geophysical data are presented in Idaho State Plane Coordinates, East Zone, NAD 83. Control points for these surveys are provided below. Units are feet.

POINT	NORTHING	EASTING	DESCRIPTION
0001	669339.304	423071.985	NWCORNERPIT6
0002	669318.770	423510.014	NECORNERPIT6
0003	669197.678	423489.698	SECORNERPIT6
0004	669225.960	423007.639	SWCORNERPIT6
0005	669387.780	422092.921	NWCORNERPIT4
0006	669341.284	423068.976	NECORNERPIT4
0007	669226.950	423005.629	SECORNERPIT4
0008	669276.865	422103.548	SWCORNERPIT4
0009	669250.871	422103.688	NWCORNERPIT10
0010	669193.068	423202.784	NECORNERPIT10
0011	669096.961	423180.328	SECORNERPIT10
0012	669119.423	422373.374	SOUTHCORNERPIT10
0013	669184.947	422114.065	SWCORNERPIT10

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Appendix B

GeoSense Report

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**Surface Geophysical Surveys at INEEL Pit 9 Conducted Under
Phase 1 of the OU 7-10 Contingency Project**

**FINAL REPORT
January, 1999**

Submitted to Parsons Infrastructure and Technology, Inc.

by

**GeoSense
Idaho Falls, ID
Under Subcontract No. 734456-T-2821-S002-99**

Introduction

This report discusses results from surface geophysical surveys conducted at Pit 9, which is located at the Idaho National Engineering and Environmental Laboratory's (INEEL) Subsurface Disposal Area (SDA). The SDA is part of the INEEL Radioactive Waste Management Complex and has been used for burial of radioactive and hazardous waste since about 1960. Pit 9 contains wastes generated at the DOE Rocky Flats Plant and is the focus of a three-stage waste remediation program aimed at mitigating potential environmental threats. Process knowledge of Rocky Flats operations indicates that plutonium bearing sludge waste was packaged, transported and buried at Pit 9 within 55 gallon steel drums. This waste, known as Series 74 sludge, is the primary target of planned remedial actions. The surface geophysical surveys were conducted to obtain a general understanding of the distribution of buried metallic debris for use in planning the Pit 9 remedial program.

Stage 1 of the Pit 9 remedial program calls for installation of at least 18 cased probeholes into a selected 40 ft by 40 ft subsection of Pit 9. The probeholes will permit detailed subsurface measurement of radioactive and chemical constituents. Surface geophysics will be used to select the 40 ft by 40 ft Study Area and guide placement of the probeholes. Specifically, the Study Area will be selected in a location that has a geophysical signature consistent with 55 gallon drum waste. Initially the probeholes will be located uniformly throughout the Study Area, and then adjusted if necessary to preferentially sample or avoid portions of the Study Area having characteristics inferred from the geophysical data. The principal characteristics of interest are 1) presence or absence of metal waste, and 2) presence of massive objects that could prohibit probehole installation.

Geophysical methods

Rocky Flats waste records show that a great variety of waste materials were buried at Pit 9. These materials include assorted metallic debris such as the Series 74 sludge drums, drums containing other types of waste, large metal objects, and boxes containing loose metal waste. Magnetic field and electromagnetic induction measurements permit accurate mapping of the location of metallic debris in the subsurface. These methods have been widely used in buried waste characterization.

Magnetic field mapping involves measurement of disturbances of the earth's magnetic field caused by the presence of ferrous metal objects. Most iron and steel materials behave as weak magnets when placed in an external magnetic field such as the earth's magnetic field. High sensitivity magnetic field detectors can measure the magnetic disturbance created by these objects. The magnetic disturbance falls off rapidly with distance from the object, but large objects such as 55 gallon drums can be detected from distances of 10 or more feet under low noise conditions.

Electromagnetic induction mapping operates by creating a time varying magnetic field, which causes electric currents to flow in nearby conductive objects. The induction instrument then measures the secondary magnetic field associated with these currents. As with the magnetic method, the secondary magnetic fields fall off rapidly with distance from the object, but objects such as 55 gallon drums can be detected over nearly the same range as for magnetic field mapping systems.

The principal practical difference between magnetic field and electromagnetic induction systems is that magnetic field systems respond only to ferrous iron and steel, while induction systems will

respond for any strong electrical conductor such as aluminum, lead, copper etc. Both methods permit accurate mapping of the location of metal debris but, in general, provide limited information on the specific nature of the buried objects, particularly in a heterogeneous environment such as a waste pit. However, specific target materials may sometimes be recognized based on characteristics of the geophysical data such as the amplitude and pattern of the measured signals, the comparison between different geophysical data sets, or through integration of historical information.

Additional surveys

The United States Geological Survey (USGS) and the University of Kansas conducted two additional geophysical surveys at Pit 9 under the Department of Energy (DOE) Technology Development Program. Both techniques are variations of the electromagnetic induction technique. The United States Geological Survey operated their VTEM system, which transmits a pulsed primary field and records the time progressive decay of secondary fields associated with buried metal objects. The University of Kansas operated a commercial electromagnetic induction instrument, which transmits variable frequency primary fields and records secondary fields as a function of frequency. Both systems may potentially yield information on the depth of metal targets. Results from these surveys were not available for integration with this report, but will be available in the near future.

Dataset summary

The magnetic and electromagnetic (EM) induction surveys discussed in this report were conducted per direction of the "Work Plan for Stage I of the Operable Unit 7-10 Contingency Project"¹. Magnetic data were collected using the RGS-10 mapping system, which employs a fluxgate magnetic gradiometer to measure the z-component of the magnetic field as well as the vertical gradient of the z-field. The RGS-10 uses a measuring wheel to trigger data collection as the sensor is deployed along straight line profiles between known points. The electromagnetic induction data were collected using the EM61 system, which uses a pulsed primary field and dual receiver coils to measure secondary fields generated in the vicinity of buried metal objects. The EM61 employs a measuring wheel system identical to the RGS-10 for position measurement along straight line profiles.

Data were collected with each instrument over a fine grid and a coarse grid as shown in Figure 1. The coarse grid encompasses the entire Pit 9 area except for the northernmost 100 feet which is occupied by a waste retrieval support building. Coarse grid data were collected along profiles spaced one meter apart. The fine grid encompasses the 40 ft by 40 ft Study Area selected for Phase I activities. Fine grid data were collected on profiles spaced one foot apart. Sheet piles, reinforced concrete pads and steel rails were recently installed immediately adjacent to the western and eastern Pit 9 boundaries. These structures created significant measurement interference over the western and eastern margins of all the surveys.

The coarse and fine grid limits were established using Pit 9 survey benchmarks to define baseline endpoints. Data profiles were then collected from a known baseline point to a second known point on a parallel baseline, with data point measurement triggered by the measuring wheels at

¹ DOE-ID, 1998, "Work Plan for Stage I of the Operable Unit 7-10 Contingency Project", U.S. Department of Energy Idaho Operations Office Report No. DOE/ID-10623, Department of Energy Idaho Operations Office, Idaho Falls, ID.

approximately six to eight inch intervals along the profile line. During data processing, data point positions were computed based on the known distance from baseline to baseline. Position accuracy is estimated as \pm six inches in any direction.

Interference caused by recent construction along the edges of Pit 9 resulted in approximately 10 - 15 ft wide "blind" zones along the eastern and western edges of the Pit. Since the western blind zone passes through the Study Area, a pre-construction magnetic survey was required to provide a complete picture of metallic waste distribution. A high resolution magnetic survey conducted in 1992 using a prototype version of the RGS-10 was recovered for this purpose². An approximate coordinate system conversion was performed based on aligning corresponding magnetic field features captured by both surveys. This conversion is estimated to be accurate to about 2 feet, and permits the old survey to be used for interpreting the Pit margins.

Figure 1 also shows the approximate location of test excavations conducted at Pit 9 in 1977. The report "Initial Drum Retrieval Final Report" documents the contents of these excavations³. The Figure 1 representation of these excavations was generated by an approximate coordinate conversion based on a drawing in Figure 6 of Reference 3, which shows several Pit 9 boundary markers that were assumed to be identical (or very close) to the current boundary markers. The conversion is estimated to be accurate to within about 5 - 10 feet.

Table 1 provides statistics for each of the geophysical data sets presented in this report.

Table 1. Statistics for surface geophysical surveys at Pit 9.

<u>Survey</u>	<u>Instrument</u>	<u>Measurement</u>	<u>Total Area</u>	<u>Data points</u>	<u>Data points/sq ft</u>
1996 full pit magnetics	RGS-10	z-component magnetic field; vertical gradient magnetic field	30,741 sq ft	12,211	0.4
1996 Study Area magnetics	RGS-10	z-component magnetic field; vertical gradient magnetic field	2,700 sq ft	3,700	1.4
1996 full pit EM induction	EM61	Induced field, upper and lower coils	30,741 sq ft	13,920	0.5
1996 Study Area EM induction	EM61	Induced field, upper and lower coils	2,700 sq ft	3,960	1.5
1992 full pit magnetics	Prototype RGS	z-component magnetic field; vertical gradient magnetic field	60,980 sq ft	45,670	0.8

Pit 9 geophysical maps

Map representations of the full Pit 9 geophysical surveys are presented in Figures 2 - 4. Figures 2 and 3 show the 1998 magnetic and electromagnetic data sets respectively. Figure 3 shows the 1992 magnetic data. Data are color coded by measured intensity values. Relevant cultural and interpretive features are overlaid and annotated for reference. Note the noise dominated "blind" zones in the 1998 maps and the high degree of correlation between the two magnetic data sets and.

² Roybal, L. G., G.S. Carpenter and N.E. Josten, 1992, "Rapid Geophysical Surveyor Final Report", EG&G Idaho Report No. EGG-WTD-10566, EG&G Idaho, Inc., Idaho Falls, ID.

³ McKinley, K.B. and J.D. McKinney, 1978, "Initial Drum Retrieval Final Report", EG&G Idaho Report No. TREE-1286, EG&G Idaho, Inc., Idaho Falls, ID.

Study Area geophysical maps

Map representations of the Study Area geophysical survey data are presented in Figures 5 and 6. Data are color coded according to the measured intensity values. Interpretive features are overlaid and annotated for reference.

Interpretation

The following observations are made with reference to the Figure 2 - 6 geophysical maps. Interpretive conclusions are presented to address the stated objectives of the Stage 1 surface geophysics program. Uncertainty associated with these conclusions is also discussed.

Figures 2 - 4 provide information regarding the overall distribution of metallic waste in Pit 9. The Figure 4 magnetic data, which was collected prior to construction of the large rail structures that flank the western and eastern Pit margins, supplies coverage for the extensive interference zones observed in the 1998 data. The interference, which is most severe in the magnetic data, effectively masks the response of metallic objects buried near the eastern and western margins of the Pit. The following observations and conclusions are presented with reference to Figures 2 - 4:

1. The 1992 and 1998 magnetic data show nearly identical features except along the edges where severe interference degrades the 1998 data set. Small differences between the surveys are due to the presence of several feet of additional soil overburden in 1998, differences between the magnetometers utilized in the two surveys, and slight errors associated with converting the data sets into a common coordinate system. For the present qualitative purposes, the recovered 1992 data are judged to be fully reliable.
2. All three data sets support the interpretation of a large irregularly shaped waste "block" that appears to have a higher concentration of buried metal than adjacent areas. This waste block (shown by a red outline) encompasses the portions of Pit 9 that received large shipments of Rocky Flats 55 gallon drums between 5/68 and 8/68 based on shipping manifests. Four of the ten 1977 trial excavations within this waste block produced clear evidence of buried drums, including the two largest and southernmost excavations (see Figure 4 overlay). Based on this evidence, the Phase 1 Study Area location appears to be well situated to intersect buried 55 gallon drums.
3. The northern lobe of the interpreted waste block (i.e. north of about coordinate 669575N) has a higher likelihood of containing large or massive objects judging from the general character of the geophysical signatures. This judgment is based on the high anomaly amplitude and more continuous anomaly area observed in this region. However, this interpretation is speculative since many factors (such as shallow burial depth and superposition of multiple objects) can create this anomaly character.
4. Two locations, marked "A" and "B" in Figures 2 - 4, show the positions of prominent non-ferrous metal objects. These objects may be composed of high quality stainless steel, lead, aluminum, copper or other non-magnetic metal. A careful comparison with shipping manifests may reveal the identity of these objects.

Figures 5 and 6 show detailed information regarding the distribution of metallic waste in and around the Phase 1 Study Area. The following observations and conclusions are presented with reference to these Figures:

1. The magnetic and electromagnetic data show a substantially identical distribution of buried metallic waste in and around the Study Area. The metal waste content may be subdivided into four waste blocks as indicated by the red lines in Figures 4 and 5. These blocks were interpreted based on changes in geophysical signature and may contain materials differentiated from each other by their physical character, date of disposal, or the presence of intervening fill material. Any of these scenarios is consistent with the dumping of waste in distinct batches.
2. Block 1 waste is part of a larger waste block that occupies much of the southeast portion of Pit 9. The southernmost 1977 excavation occurred within this waste block. At least four of the planned probehole locations will sample Block 1.
3. The Block 2 waste boundary was drawn based on the 1992 magnetic data (Figure 4) since interference effects obscure the 1998 datasets in this portion of the Study Area. The 1992 magnetic data suggest that waste in this block was buried in an orderly row extending along the Pit 9 margin for about 100 feet beginning near the southwest corner of the Study Area. At least three of the planned probehole locations will sample Block 2.
4. Block 3 waste suggests an isolated area of ferrous metal debris flanked on two sides by areas containing minimal metallic waste (marked as "A" and "B" in Figures 4 and 5). This block is not otherwise clearly distinguishable from Blocks 1 and 2. Two of the planned probeholes will sample near the margins of Block 3, but should be shifted slightly to increase the probability of intersecting the metal waste.
5. Block 4 displays a low amplitude signature in both the magnetic and electromagnetic data sets, spanning a narrow line between Blocks 1 and 2. This waste block is interpreted to contain a relatively small amount of metal debris and is distinguishable only because it occurs within one of the large zones having very little metallic debris (see marker "A" in Figures 4 and 5). The planned probeholes sample only the perimeter of the interpreted block.
6. None of the indicated buried metallic objects within the Study Area stands out as being uniquely large or massive based on geophysical character. The highest intensity anomalies in Figures 4 and 5 occur just south of the southeast corner of the Study Area.

Conclusions

Surface geophysical data show that the Phase 1 Study Area is located in a region consistent with the presence of Rocky Flats drum waste. The geophysical data give no clear evidence for the presence of uniquely large or massive metal objects within the Study Area. The planned probehole pattern will uniformly sample the Study Area subsurface, either intersecting or passing nearby each of four interpreted waste blocks. The exact physical significance of the interpreted waste blocks is highly conjectural but, in the absence of more substantive information, provides a basis for obtaining potentially diverse subsurface samples. Direct information provided by the Phase 1 probehole activities may be useful for "calibrating" the geophysical data, which can then be used more definitively for choosing a Phase 2 excavation site.

Appendix A - Coordinate Systems

Appendix A provides a brief discussion of the coordinate system utilized for presenting the Pit 9 surface geophysical data.

INEEL RWMC Site Specific Coordinates

The reference coordinate system for the Pit 9 project is the INEEL RWMC Site Specific Coordinate System (IRSSCS). The IRSSCS utilizes a non-standard coordinate projection that provides a high degree of accuracy at the INEEL RWMC. The IRSSCS projection parameters were not readily obtainable at the time this report, but may be requested directly from the INEEL.

Pit 9 and Phase I Study Area corner points were established and flagged prior to initiating the geophysical surveys. Table A-1 gives the IRSSCS coordinates for these reference points. The geophysical surveys were laid out relative to these reference points. Consequently, all data presented in this report conform to the IRSSCS system.

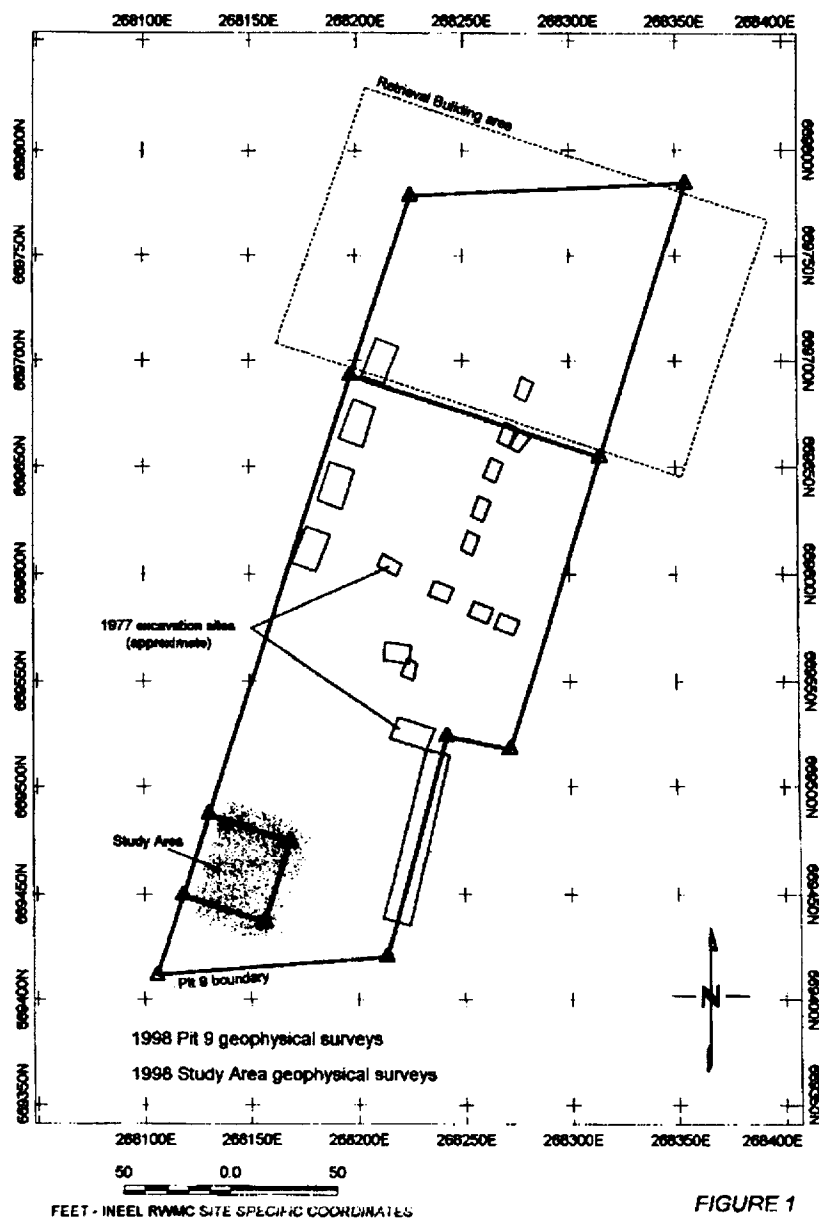
Table A-1. Pit 9 reference point coordinates in the INEEL RWMC Site Specific Coordinate System.

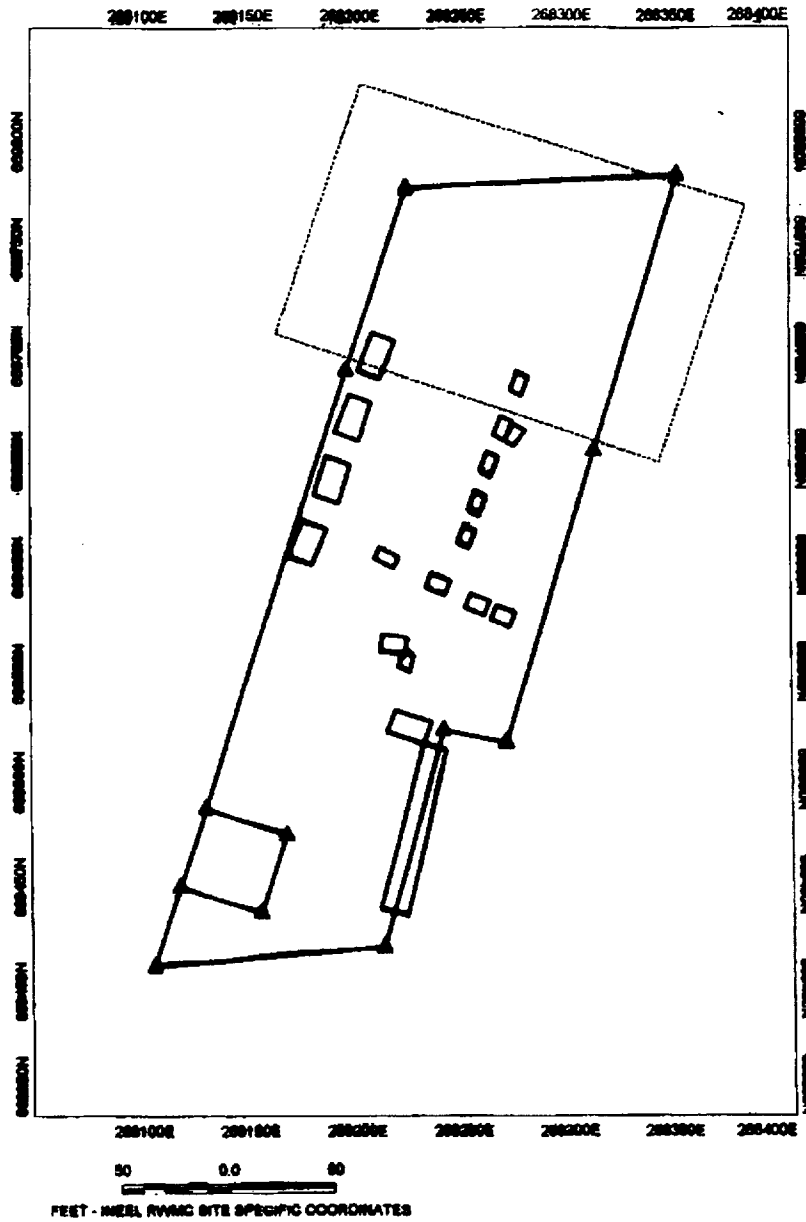
<u>Index</u>	<u>IRSSCC easting (feet)</u>	<u>IRSSCC northing (feet)</u>	<u>Description</u>
1	268225.79	669778.30	Pit 9 NW corner
2a	268130.69	669487.42	Study Area NW corner
3a	268118.26	669449.40	Study Area SW corner
4a	268156.28	669436.97	Study Area SE corner
5a	268168.71	669474.99	Study Area NE corner
6	268105.83	669411.38	Pit 9 SW corner
7	268213.89	669420.26	Pit 9 SE corner
8	268242.29	669523.43	Pit 9 west jog
9	268272.03	669517.07	Pit 9 east jog
10	268354.84	669784.28	Pit 9 NE corner
11	268240.57	669379.30	Point on east berm
12	268533.54	670066.60	RWMC North (primary reference point)
13	268197.83	669692.75	Retrieval building area, west end
15	268314.64	669654.57	Retrieval building area, east end

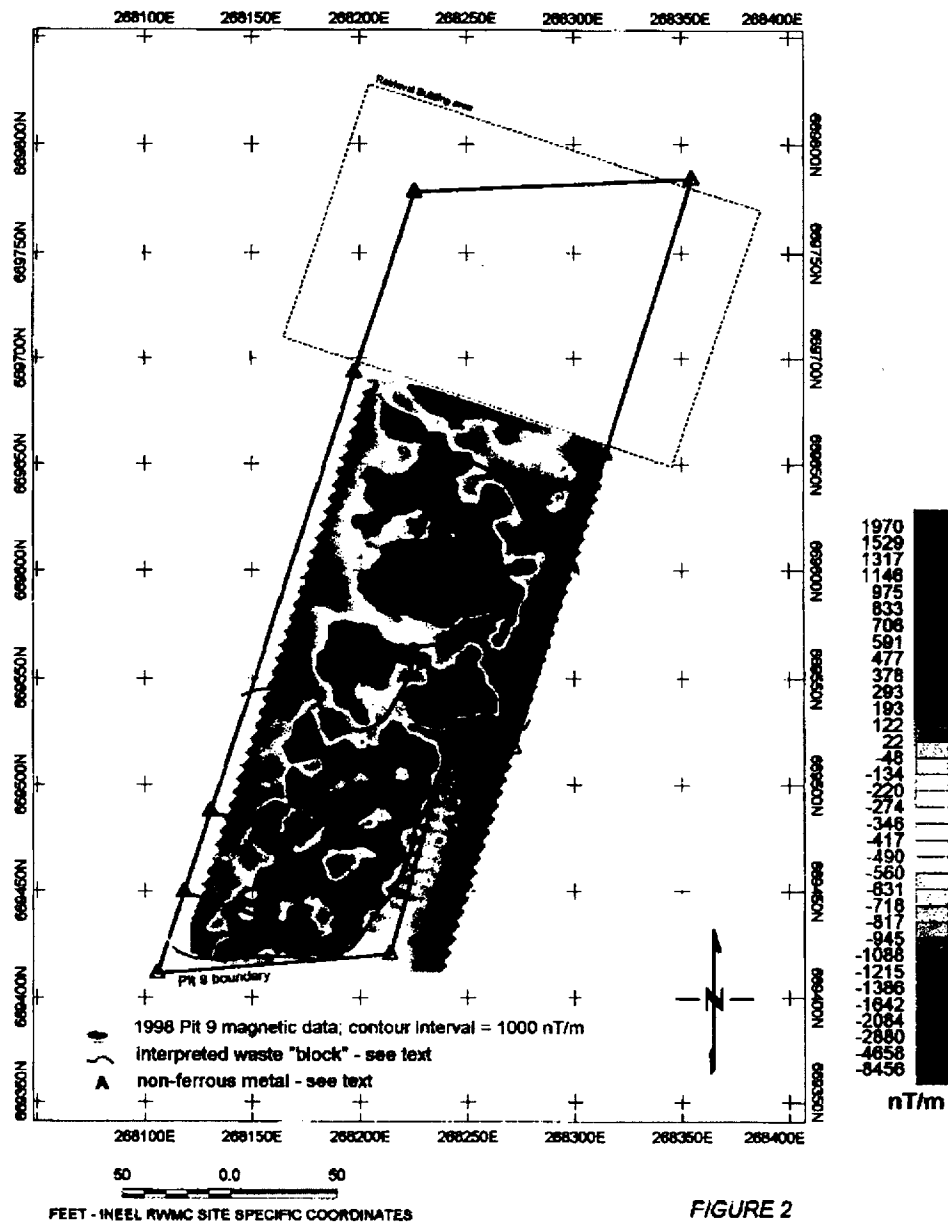
Coordinate conversions

Coordinate conversions were performed in order to compare the 1977 Pit 9 trial excavations and the 1992 Pit 9 magnetic field with the newly collected data. To make these conversions it was first necessary to identify common points between the old data sets and the IRSSCS system. Pit 9 corner marks were used to reference the 1977 excavation data. Prominent magnetic field peaks were used to reference the 1992 magnetic survey data. The common points provided a basis to develop rotation, translation and scale factors to approximately convert the older data sets into the IRSSCS system.

The 1977 excavation data conversion is inexact because it was based on a sketch drawing of the excavation sites. Any position errors contained in the initial drawing are preserved in the converted data set.







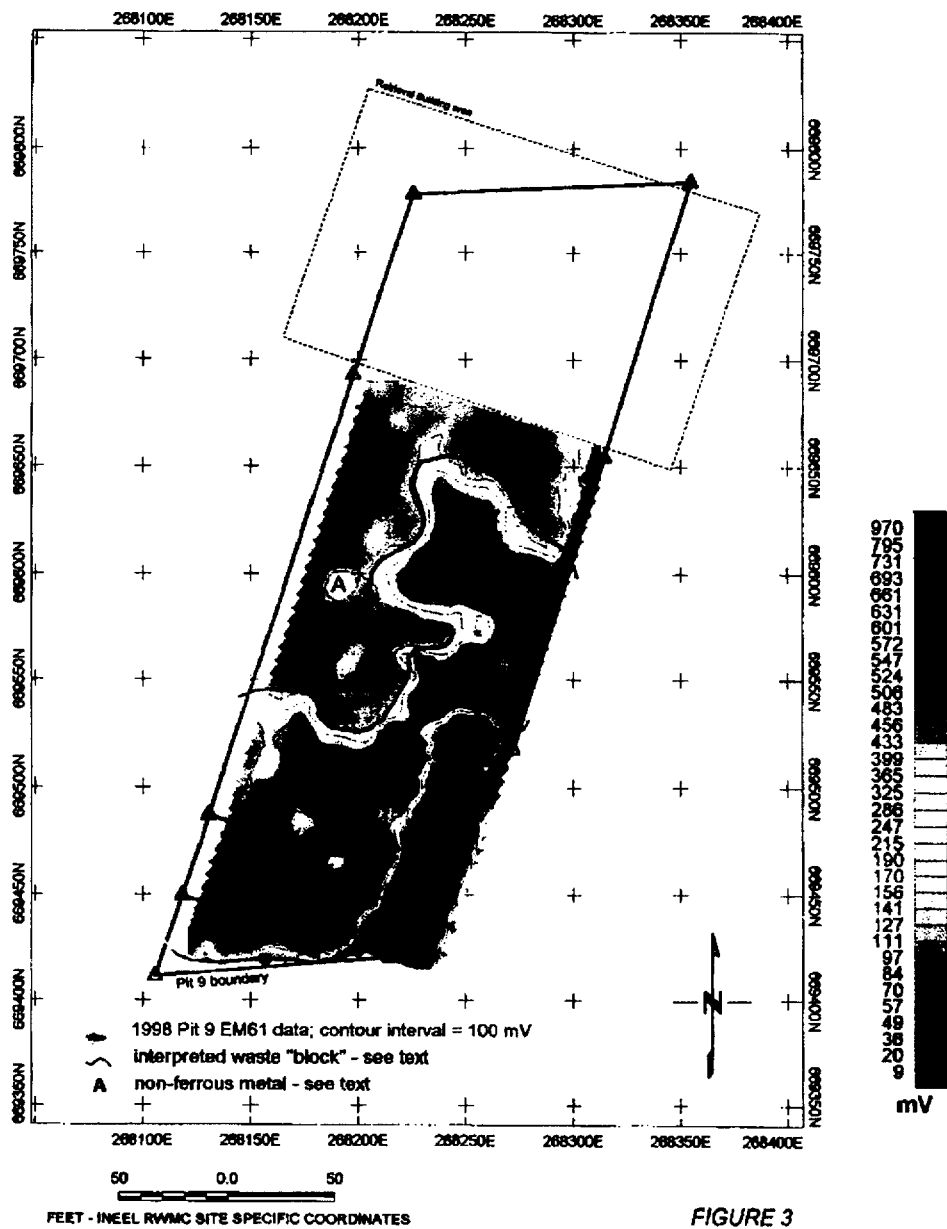


FIGURE 3

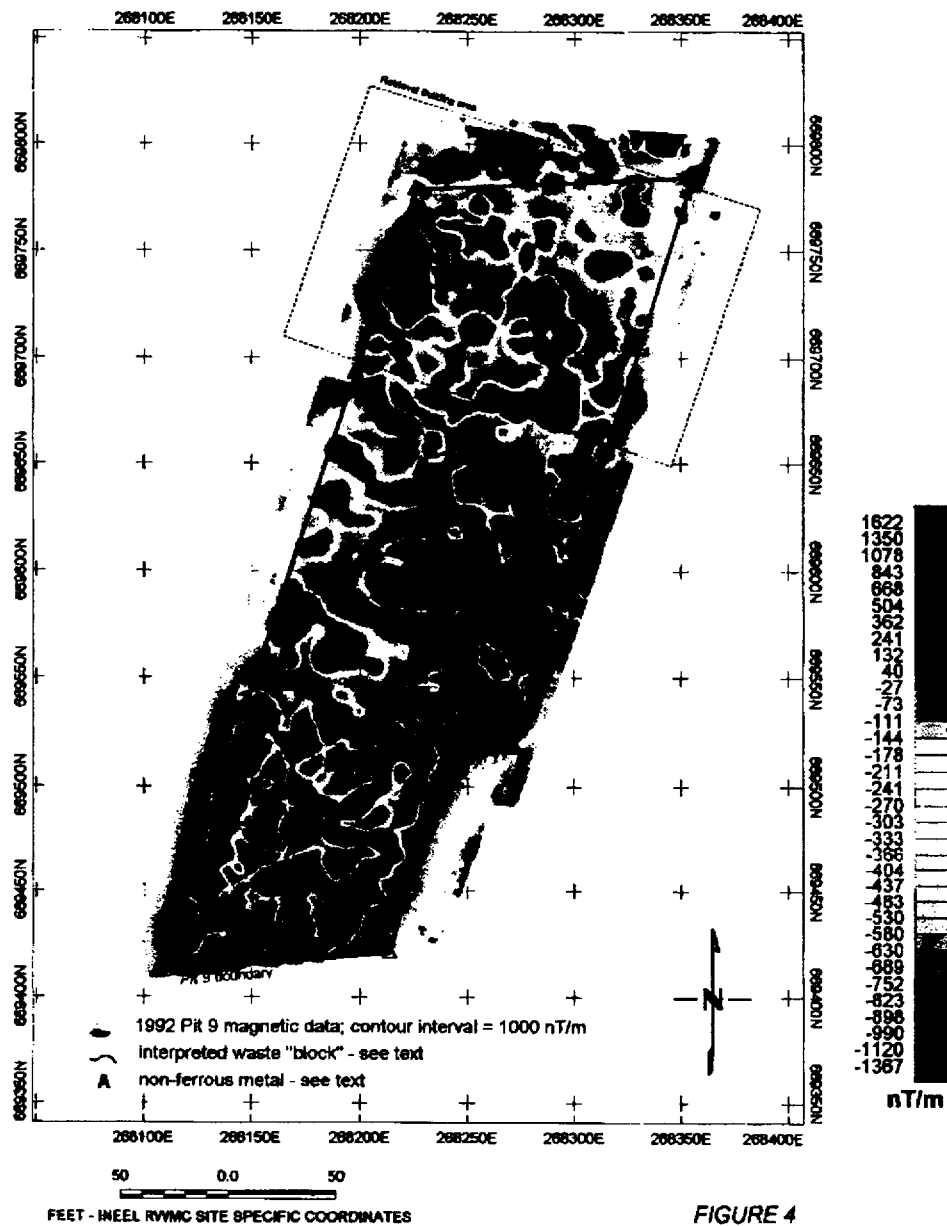


FIGURE 4

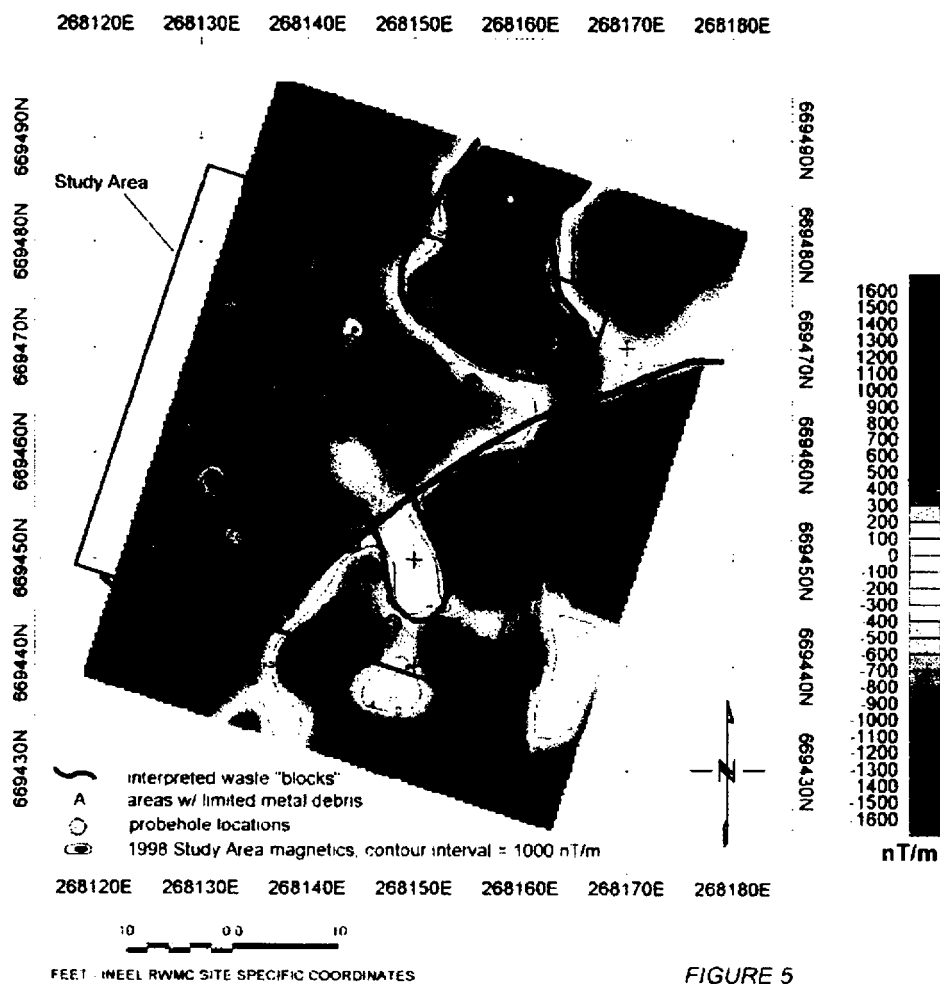


FIGURE 5

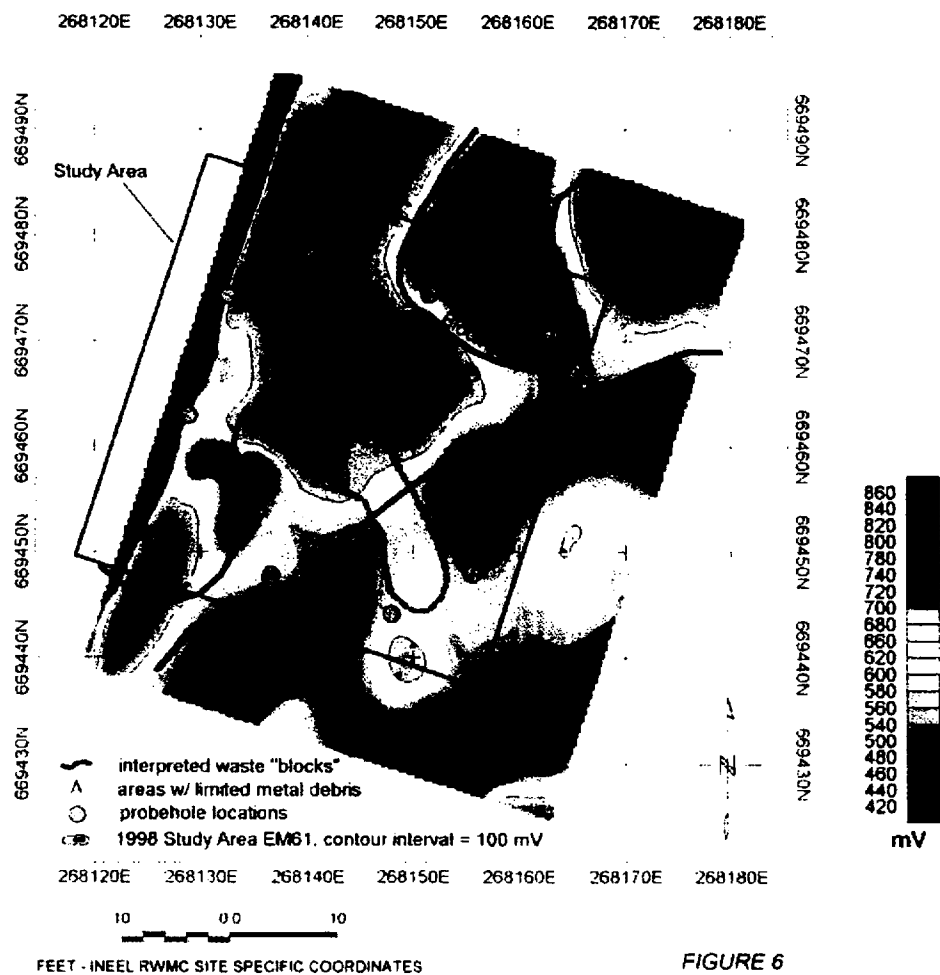


FIGURE 6